

MODELING A COMPRESSION VALVE GEOMETRY OF A MONO-TUBE SHOCK ABSORBER FOR A CONSTANT DAMPING FORCE

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Abstract

The purpose of this paper is to ascertain the variation of the compression valve interstice geometry versus the damper velocity, for a mono-tube shock absorber, in order to achieve the damping with a constant force.

Keywords: shock absorber, damping force, compression, rebound, valve, flow rate, coefficient of discharge

NOMENCLATURE:

Q - flow rate;
 p - pressure;
 v - velocity;
 x - piston stroke;
 D - diameter of the piston;
 d - diameter of the rod;
 F_a - damping force;
 S - interstice area;
 ρ - oil density;
 SC - compression valve;
 SD - rebound valve;
 C_d - coefficient of discharge
 c - compression;
 p_{Ac} - pressure in chamber A during the compression stage;
 p_{Bc} - pressure in chamber B during the compression stage.

1. INTRODUCTION

A hydraulic shock absorber transforms the kinetic energy of an elastic system oscillating motion into heat, that, than, will be dissipated outwards. This phenomenon is due to the friction force that is developed by the flow of the fluid through the calibrated interstices of the shock absorber. In the automobile industry, the hydraulic shock absorber performances have a large influence both over the vehicle stability and over the comfort of the passengers. In all the cases, the design of the shock absorber is a compromise between comfort and stability.

The hydraulic double acting shock absorber has a dual effect, because it damps the suspension oscillations both in the compression stage and in the rebound stage, obviously with a higher energy in the rebound stage.

2. THE PHYSICAL MODEL AND THE MATHEMATICAL MODEL OF THE SHOCK ABSORBER

The physical and the mathematical model of the shock absorber are presented in Fig. 1.

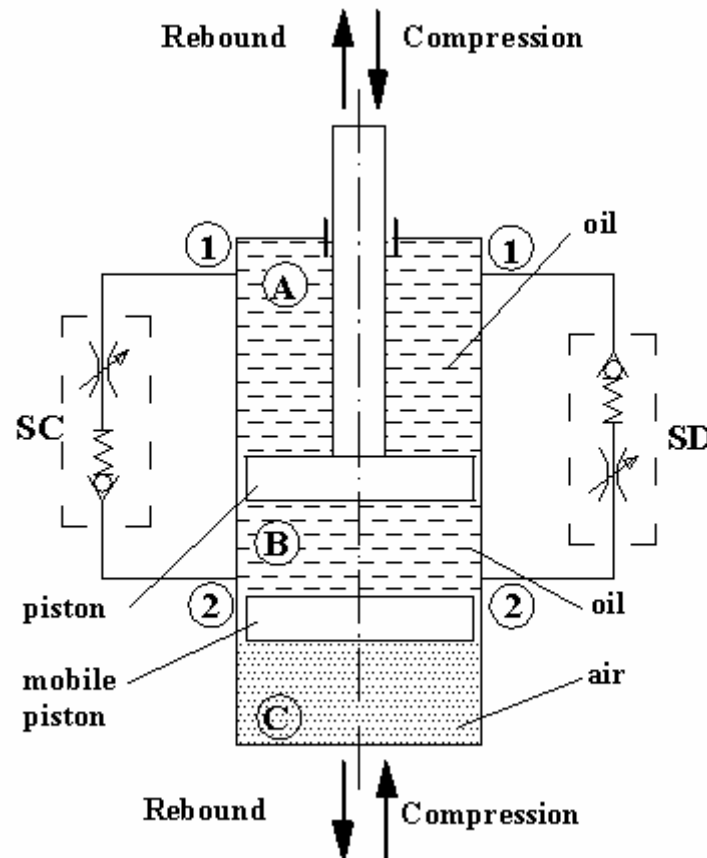


Fig.1. The physical model of the shock absorber

During the rebound stage (when the shock absorber piston is moving outwards from the cylinder), only the SD element is active, and during the compression stage (when the shock absorber piston is moving inwards from the cylinder), only the SC element is active.

The mathematical model of the shock absorber comprehend the following equations:

- the continuity equation in the node 2:

$$S_B \cdot \dot{x} = Q_{SC_c} \quad (1)$$

- the continuity equation in the node 1:

$$S_A \cdot \dot{x} = Q_{SD_c} \quad (2)$$

- the equilibrium equation of the forces:

$$F_{ac} = S_B \cdot p_{Bc} - S_A \cdot p_{Ac} \quad (3)$$

Because:

$$p_{Ac} \ll p_{Bc} \quad (4)$$

the term $S_A \cdot p_{Ac}$ can be neglected and (3) becomes:

$$F_{ac} = S_B \cdot p_{Bc} \quad (5)$$

The oil flow rate that passes from the compression valve is depending on the valve drop pressure and on the valve cross areas, in according with the expression:

$$Q_{SCc} = C_{dSC} \cdot S_{SC} \cdot \sqrt{\frac{2\Delta p_{SC}}{\rho}} \quad (6)$$

where :

Δp_{SC} is the drop pressure through the compression valve and can be calculated with:

$$\Delta p_{SC} = p_{Bc} - p_{Ac} \quad (7)$$

According to (4), the term p_{Ac} can be neglected, and thus,

$$\Delta p_{SC} = p_{Bc} \quad (8)$$

From (1), (6), and (8) one obtains:

$$S_B \cdot \dot{x} = C_{dSC} \cdot S_{SC} \cdot \sqrt{\frac{2p_{Bc}}{\rho}} \quad (9)$$

The pressure of the compression chamber during the compression stage can be calculated from (5):

$$p_{Bc} = \frac{F_{ac}}{S_B} \quad (10)$$

By substituting (10) in (9), and knowing that $\dot{x} = v$, the variation function of the compression valve geometry interstice will be obtained with regard to the parameters of the shock absorber:

$$S_{SC} = \frac{\left(\frac{\pi D^2}{4}\right)^{3/2} \cdot v \cdot \sqrt{\rho}}{\sqrt{2} \cdot C_{dSC} \cdot \sqrt{F_{ac}}} \quad (11)$$

The expression (11), obtained for the valve interstice cross area, shows that *to a constant damping force, the cross area of the compression valve interstice is a linear function of the shock absorber velocity.*

3. NUMERICAL APPLICATION

A shock absorber employed to the Dacia car suspension has the following characteristics:

$$\begin{aligned}
 D &= 35\text{mm} \\
 P &= 800\text{kg/m}^3 \\
 C_{dSC} &= 0.75 \\
 F_{ac} &= 1000\text{N} \\
 0 &< v < 2\text{m/s}
 \end{aligned}$$

In Fig. 2 the resulting dependence of the compression valve cross-area interstice versus this shock absorber velocity in the compression stage, for a given damping force, is presented.

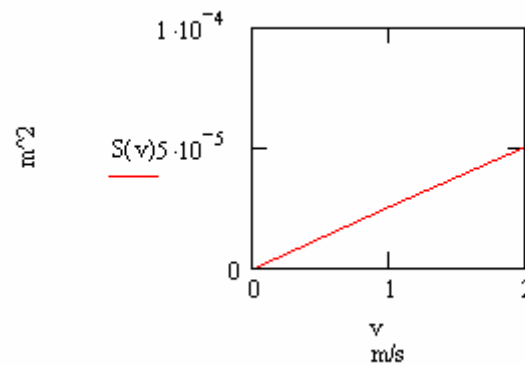


Fig.2. The valve cross-area versus the shock absorber velocity

4. CONCLUSSIONS

This paper offers a mathematical support for the calculus and for the design of the shock absorber valve cross-area at a constant damping force.

References

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